Designing a podiatry service to meet the needs of the population: a service simulation

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Abstract

A model of a podiatry service has been developed which takes into consideration the effect of changing access criteria, skill mix and staffing levels (among others) given fixed local staffing budgets and the foot-health characteristics of the local community. A spreadsheet-based deterministic model was chosen to allow maximum transparency of programming.

This work models a podiatry service in England, but could be adapted for other settings and, with some modification, for other community-based services. This model enables individual services to see the effect on outcome parameters such as number of patients treated, number discharged and size of waiting lists of various service configurations, given their individual local data profile. The process of designing the model has also had spin-off benefits for the participants in making explicit many of the implicit rules used in managing their services.

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What is known about the topic?
Podiatry services in the UK are typically planned according to historical precedent, local practice and financial imperative. Although it is National Health Service policy in England for local service needs to be determined locally, this is rarely practical with the resources available. No previous computer simulations of podiatry services have been developed.

What does this paper add?
This paper presents the first computer model of a podiatry service. It allows service managers and planners to see the effects of different service configurations on meeting the demand for podiatric care in their locality. It can quantify the effect of a range of different parameters, such as staffing profile and the lengths of episodes of care, on the ability of a service to deliver appropriate levels of care to their population.

What are the implications for practitioners?
By collecting simple audit data on podiatric pathologies presenting for treatment and the treatment pattern of those pathologies, managers and planners can tailor the model to suit their own service needs. It can be used both for routine planning of staffing needs and for "what if" analysis for service innovation or reconfiguration.

PODIATRISTS DEAL WITH the assessment, diagnosis and treatment of the lower limb. In the United Kingdom, most podiatry services offered by the National Health Service (NHS) are in the primary care sector. Since 2000, decisions relating to planning for podiatry services available under the NHS in England have been devolved to the local level.[1,2] The responsibility for determining need and designing services to meet those needs within budget constraints is now the responsibility of Primary Care Trusts (PCTs).

> In line with our policy of "Shifting the Balance of Power", it is now for primary care trusts, (PCTs) in partnership with strategic health authorities (SHAs) and other local stakeholders to plan, develop and improve services for local people. We recognise that health services are better when management is devolved to the frontline. Within the framework set out in the NHS Plan and other policy documents, PCTs, with their specialised knowledge of the local community, are able to effectively manage and improve local services.[3]

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However, this policy strains the planning capacity of small organisations which may result in inconsistency in the way need, access criteria and service provision are matched. This is particularly true for podiatry services, where some PCTs offer treatment on demand, including social care, while others have an exclusively high-risk service. There seems little evidence that this diversity has arisen as a direct reflection of the differences in local need. Furthermore, the effort involved in planning these services is duplicated many times across the country. A useful model that links need, access and provision could lead to consistent, fairer services and reduce the aggregated effort of numerous individual PCTs in planning the same service.

Increasingly, computer simulation of services has been used as a planning tool in a wide variety of commercial, industrial and public sector applications. In health care, simulation can assess the efficiency of existing services, answer "what if" questions relating to service reconfigurations, and design new systems. In particular, simulation techniques can forecast the effect of changes in patient demand, access criteria, staffing or physical resources, or investigate the complex relationship between the variables in a service.[4]

A model of a podiatry service would need to consider the effect of changing access criteria, skill mix and staffing levels given fixed local staffing budgets and foot-health characteristics of the local community. A simulation model would then enable individual services to see the effect on outcome parameters, such as the number of patients treated and the size of waiting lists of various service configurations, given the local data profile.

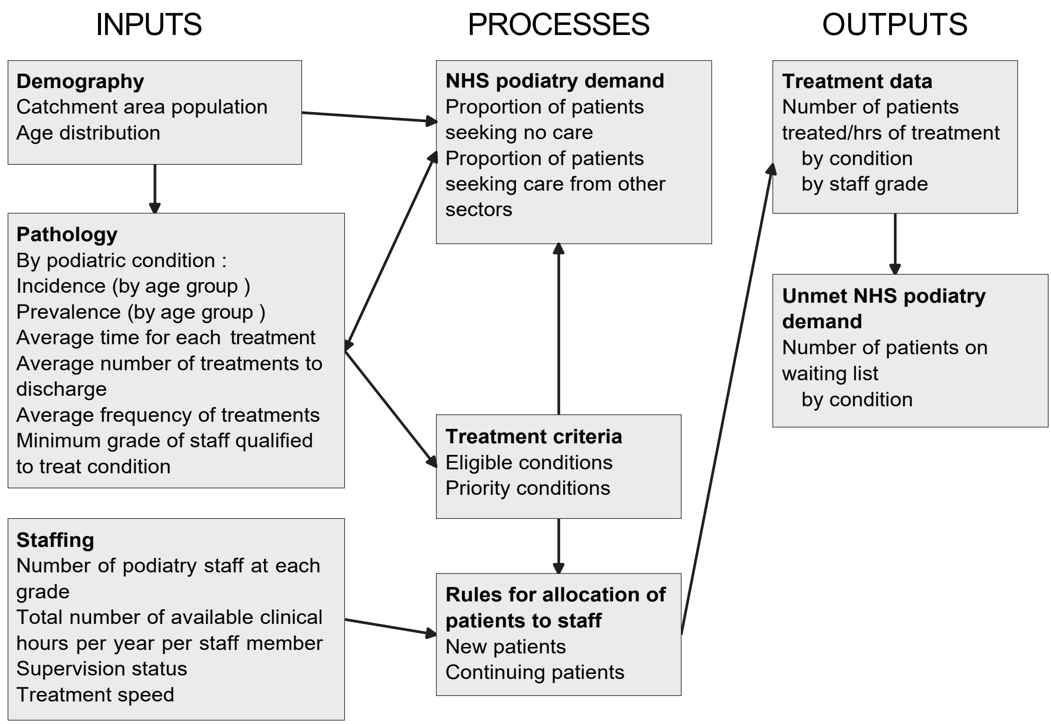
Background to the study

Accurate estimates of the prevalence and incidence of conditions requiring treatment are essential for planning both national and local services and have a direct bearing on workforce planning and commissioning of education and training. The profile of the conditions that require treatment also affects skill mix, professional development and inter-agency working arrangements.

A body of research into the prevalence of foot disorders exists, but these studies vary widely with respect to the populations surveyed, the age groups included, the definitions and scope of the conditions studied, the nature of the diagnostic process (patient report or podiatrist assessment) and the research methodology used. So although much work has been reported that examines aspects of the prevalence of foot pathology, the fact that the studies use different methodologies, taxonomies, assessment methods and ways of reporting make them virtually impossible to compare (see, for instance[5-9]). As only the Cartwright and Henderson study[6] was undertaken with a view to estimating need for podiatric care (the parameters for which have changed considerably since 1986), other studies may have only limited use for service planning. There seems to be no published work on the incidence of podiatric conditions. In addition, the relationship between podiatric need (as defined by the presence of foot conditions that should be treated by a professional podiatrist) and demand for NHS podiatric services has not been investigated. There was therefore a need for further study to provide this evidence.

A study was designed to provide this evidence, but required a major epidemiological survey. Such surveys are costly and it was therefore essential to identify those parameters that most influenced the primary outcome measures of podiatry services. The survey could then be designed to collect these data to a higher precision while less influential parameters could be based on a smaller sample size. It was felt that a deterministic model of a podiatry service would be an appropriate tool for this sensitivity analysis and was commissioned as the first phase of the research. However, as the work progressed, it was obvious that the model would provide the planning tools for podiatry managers and service planners to use once the epidemiological data were available. There have been no service simulations previously published applicable to podiatry services, and planning has been confined to

1 Systems diagram for model planning



workforce forecasting on the basis of historical data and budgetary constraints (J Chapman, NHS Workforce Review Team, personal communication, 2005), with individual service managers using their own methods for departmental planning. This paper describes the development of the podiatry service model to verification stage.

Methods

An expert "sounding board" panel was used to advise on the clinical relevance of the model during all of the phases of construction. The core panel comprised three managers of podiatry services, a senior podiatrist and a consultant community geriatrician. The panel was further expanded by additional service managers to produce a consensus on initial estimates of the input parameters. The later versions of the model were also presented to many interested groups, including the Society of Chiropodists and Podiatrists, NHS podiatry departments, the staff of a university School of Podiatry, the Allied Health Professions lead of a Workforce Development Confederation, and to a member of the NHS Workforce Review Team to gauge perceptions of its validity and usefulness. The project was overseen by a steering group from the Society of Chiropodists and Podiatrists.

Initially, a theoretical systems diagram of a typical podiatry service was constructed, which identified the input parameters, processes and outputs of a typical podiatry service (Box 1). An initial set of rules was established for the allocation of caseloads to available staff after wide consultation with the sounding board and other interested parties. Podiatry services vary widely across the country and the simulation has been designed to be tailored to suit most configurations, from single-chair clinics to large central services.

Deterministic modelling techniques were used, with a staged development approach. This enabled the modelling of annual mean outcomes, for example waiting list lengths, remaining unmet need, staff costs, number of patients treated. Preliminary discussions had indicated that annual averages were more meaningful to podiatry managers (as this was the sort of data they already collected) and there were no data on the distributions of the input parameters. It was also easier to extract rules based on an annual overview. The programming was done with linked Microsoft Excel spreadsheets (Microsoft Corporation, Redmond, Calif, USA), which were familiar to managers, so that the model was transparent for subsequent verification and validation.

Six iterations of the model were developed. The first four were the result of programming corrections and refinements. Subsequent versions were demonstrated to the sounding board and other test audiences. Version 5 refined the method of allocating treatment hours to staff by ensuring that the highest staff grades were allocated the most serious conditions before being allocated the lower grade overspill. The rules for distributing the unallocated treatment hours were changed and were allocated by condition to produce a more sensitive model of staff use. The nomenclature for staff grades in version 6 were changed to reflect new grading structures within the NHS, and the lowest grade of staff (footcare assistants) were prevented from treating conditions which required a qualified podiatrists, even under supervision.

Verification of the model (checking that the defined system has been correctly programmed) was undertaken by Professor Ray Jones of the University of Plymouth, who also ran the sensitivity analyses. The verification process consisted of programming checks and running repeated simulations with varying input parameters to check for unexpected behaviour. Full validation of the model (checking that the right model was built) will not be possible until empirical data from podiatry services, including accurate epidemiological data, are available. Face validity was established and a limited validation study based on NHS demand is currently under way with pilot podiatry services.

Results

The following section summarises the main features of the model.

User-defined inputs

Pathology data

Users can define the pathologies that their service would expect to treat. For each defined podiatric condition, the following data are required:

- Service access criteria (condition sufficient for access to service OR only if in conjunction with defined medical condition OR not eligible for treatment)
- Medical conditions (eligible for treatment with a podiatric condition defined above OR eligible for treatment without a podiatric condition)
- Is it a very high risk/emergency/priority condition?
- Minimum grade of podiatry staff (can include foot care assistants) that should treat that condition
- Average treatment frequency for that condition (eg, 3-monthly, weekly etc)
- Average treatment duration (per visit)
- Average number of treatments to discharge
- Epidemiological data
  - Prevalences (by age group)
  - Incidences (by age group)
  - Need : demand ratio (making allowances for those who seek treatment from other sources eg, from private practice or those who will not seek treatment.)

Service data (individual annual profiles for 5 years)

- Demographic profile for catchment area (population numbers for each age group)
- Staffing profile (per staff member)
  - Staff name (not required)
  - Total number of clinical contact hours per year
  - Staff grade (There are currently 4 staff grades identified in the model, which can be user-defined. More could be included if required)
  - If supervision/mentoring is available (If so, staff member can treat conditions specified for one grade above [not for foot care assistants])

  - Time adjustment (Continuous sliding scale to allow for slower throughput of, eg, students, new staff, supervising/mentoring senior staff or faster throughput of experienced staff)

Outputs

- By podiatric condition, per year:
  - number of contacts
  - number of patients treated
  - number of completed treatments/discharged patients
  - unmet demand (number of untreated patients)
- Patient distribution to staff by grade:
  - Priority/non-priority cases
  - Continuing/new cases
  - Treated patients by condition

Model rules and assumptions

Eligibility for treatment

The model recognises that in the UK each NHS podiatry service sets its own criteria for who is eligible for treatment and allows the planner to define which podiatric conditions are eligible for treatment. In addition to a condition being eligible in its own right, it also includes the options of defining that the condition is eligible only if there are other underlying medical conditions. For example, some services may treat all patients with corns, others may only treat corns if the patient is diabetic. Finally, there is provision for a service to define medical conditions that they would consider eligible for treatment even in the absence of a podiatric condition. Diabetic monitoring programs would come under this category.

The model also has provision for the definition of priority, or urgent, conditions to prevent conditions such as ulceration, which require urgent attention, from being deferred to subsequent years.

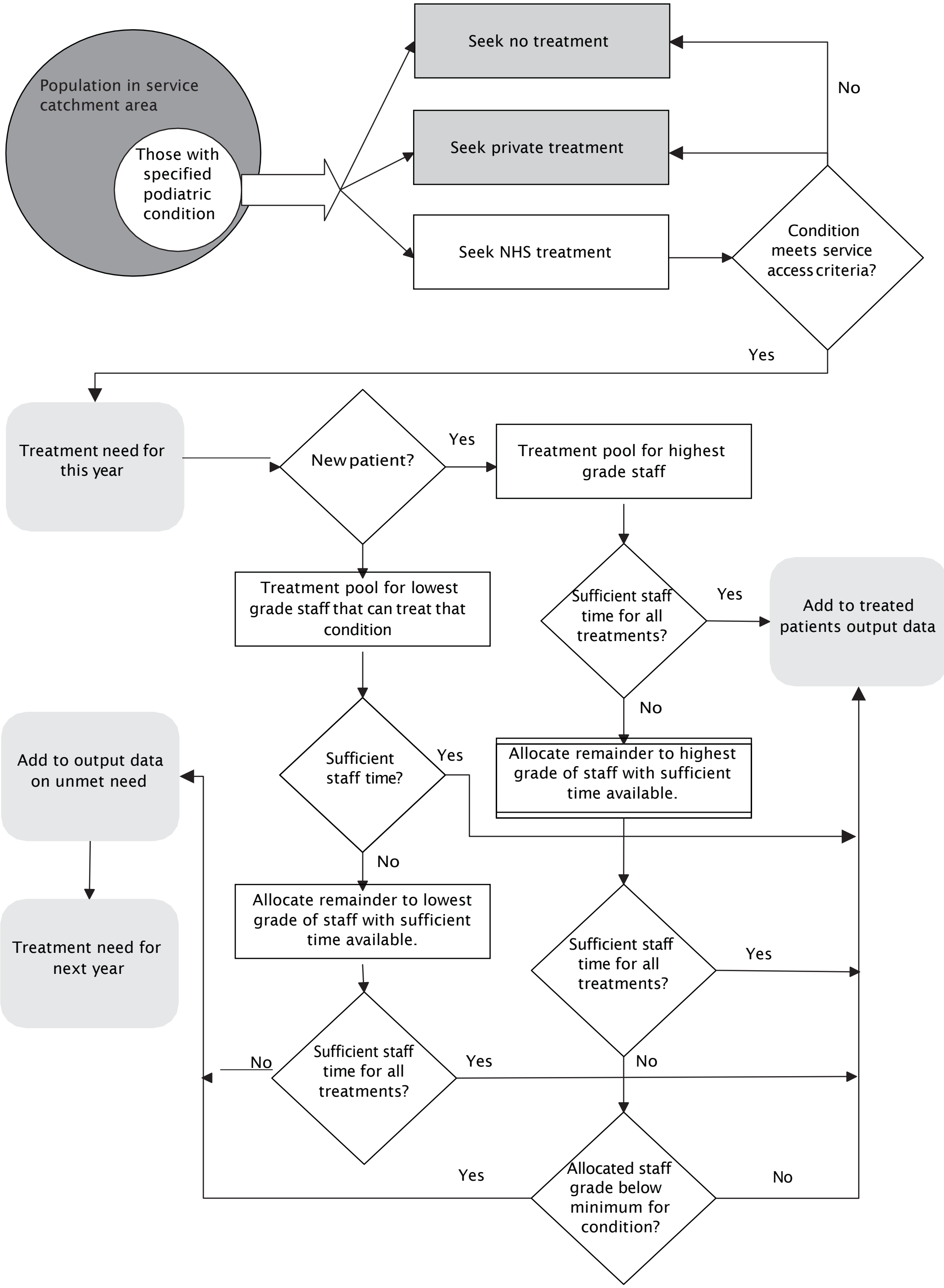
Rules for allocation of staff time

The model allocates available staffing hours to annual treatment demand. Staffing hours are defined as the number of hours per year that each member of staff has available for direct patient contact and are summed according to staff grade. Input parameters for each staff member not only reflect the amount of time for which they would expect to be treating patients, but also whether they were under supervision. It is assumed that if supervision were available for a junior member of staff, then they would be able to treat conditions that would normally be reserved for one grade above. This does not apply to the most junior staff (footcare assistants) who are unregistered and would not be permitted to perform treatments which required a qualified podiatrist. Finally, a continuous speed variable is included for each member of staff so that managers can reflect the decreased treatment time that comes with experience and other factors. In particular, this was felt to be useful in recognising that new staff and students under supervision would expect a lower patient throughput.

Annual demand for treatment time is allocated according to two dimensions, each having two levels: urgency of treatment ("priority" or "non-priority") and patient status ("new" or "continuing"). Continuing patients (whose episode of care began in a previous year and is ongoing) are allocated to available staffing before "new" patients, and priority conditions are allocated before non-priority conditions. Allocation of staffing hours to the "demand pool" is therefore performed in four stages.

- Continuing "priority" conditions are allocated to staff first. Conditions are first allocated to the specified minimum staff grade to treat that condition. If all the hours for that grade have been allocated, they are allocated to one grade above, then two grades above, etc. This ensures that staff hours are used to treat conditions most appropriate to their grade and that staff time is used cost-effectively.
- Next, new "priority" conditions are allocated. As new patients need to be assessed by senior staff, to assess risk, these conditions are first allocated to the highest available grade. In practice, only the first appointment will be with the most senior member of staff. This level of discrimination is not possible with this simulation, but could be programmed in a discrete-

2 Simplified model diagram showing allocation of staff time to patients for each condition



Patients with priority conditions are allocated to staff time before those with non-priority conditions. Continuing patients are allocated to staff time before new patients.

event model. If the senior staff are fully allocated, the patients are allocated to the next lowest band and so on. If they cannot be allocated to at least the minimum specified band for that condition, then they remain unallocated and form part of the "unmet demand" for that year.
- Continuing non-priority conditions are then allocated. Staff are allocated as for continuing priority conditions.
- Finally, new non-priority conditions are allocated to the remaining staff hours, following the allocation rules for new priority conditions.

Unallocated hours are distributed equally among all conditions in the category (as above) by staff band. For example, if only 70% of new non-priority conditions that required treatment by a particular grade of staff could be allocated, then 30% of required hours for each of the new non-priority conditions that should be allocated to that grade would not be treated.

Rules for model outputs

The number of treated and untreated hours and patients for each condition are calculated. Untreated patients are added to the "demand pool" for the following year's allocations.

The number of discharged patients is calculated for each condition. Patients who have been treated but not discharged are carried forward to subsequent years as continuing patients. The demand pool (equivalent to the number of patients waiting for treatment) can be plotted for each year and staff usage data can be graphed as appropriate.

Year 1 is assumed to be a start-up year for a new service. The demand pool is therefore based on prevalence data. The demand pool for subsequent years comprises the unmet demand from the previous year, the new cases (based on incidence rates), and the continuing patients from all previous years.

Other assumptions

The model assumes that the population demographics are stable over the time period modelled. Implicit in this is the assumption that mortality rates are balanced by the rate at which the population ages. As census statistics are only available in the UK every 10 years, and the current prediction period of the model is 5 years, this is a reasonable assumption.

The model currently does not include provision for patients not attending for booked appointments ("did not attend" [DNA] rates). This will be included in the next iteration.

It is assumed that each condition requires a separate visit and that prevalences are independent. It is recognised that these assumptions will lead to some over-estimation of the treatment time required. However, multiple conditions are best modelled using a discrete event simulation. If there is sufficient evidence of its value, the principles developed in the deterministic model will be used to programme a discrete-event simulation that will allow for further tailoring to individual patient characteristics

An overview of the model is shown in Box 2. This diagram shows the process for one condition only. The complete model can be customised for any number of podiatric and medical conditions, all of which can be defined to suit the needs of the individual service.

Verification and sensitivity analysis

Verification and sensitivity analysis was undertaken by an independent expert and confirmed the face validity of the programming. The presentations to the sounding board and to groups of podiatry managers, service planners and podiatry staff also confirmed that the model was a realistic representation of podiatry services.

One apparent anomaly revealed in the verification process was that, in some circumstances, a decrease in staffing levels in Year 1 of the model led to a lower unmet need (smaller waiting lists) than when the first year was fully staffed. This was counter-intuitive and necessitated detailed scrutiny of all the programming, all of which was correct.

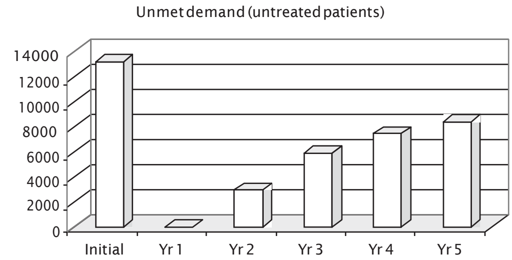
Box 3 shows an example of this. The upper graph shows the predicted unmet demand over the 5 years modelled with the upper staffing

3 Effect on unmet demand of a staffing reduction in Year 1

A: Predicted unmet demand over the 5 years modelled with the corresponding staffing profile.

Total treatment hrs/yr

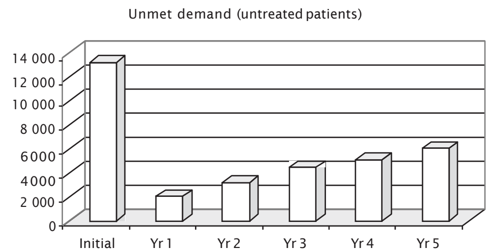
Grade	Year 1	Year 2	Year 3	Year 4	Year 5
4	1499	1499	1499	1499	1499
5	1165	1165	1165	1165	1165
5	1166	1166	1166	1166	1166
6	999	999	999	999	999
6	999	999	999	999	999
6	999	999	999	999	999
6	999	999	999	999	999
6	999	999	999	999	999
6	999	999	999	999	999
6	999	999	999	999	999
6	999	999	999	999	999
7	832	832	832	832	832
7	833	833	833	833	833



B: Effect of reducing the staffing by two staff in the first year only. All other parameters are identical.

Total treatment hrs/yr

Grad	Year 1	Year 2	Year 3	Year 4	Year 5
4	1499	1499	1499	1499	1499
5	1165	1165	1165	1165	1165
5	0	1166	1166	1166	1166
6	0	999	999	999	999
6	999	999	999	999	999
6	999	999	999	999	999
6	999	999	999	999	999
6	999	999	999	999	999
6	999	999	999	999	999
6	999	999	999	999	999
6	999	999	999	999	999
7	832	832	832	832	832
7	833	833	833	833	833



profile. The lower graph and table shows the effect of reducing the staffing by two staff in the first year only. All other parameters are identical. It can be seen that although reducing the staff has an immediate effect of increasing the unmet demand (waiting list size) in Year 1, by Year 5 the waiting list is decreased by about 2000.

Analysis of the way that patients were allocated to available staff in the two scenarios revealed that those patients not seen in Year 1 because of understaffing were all low priority conditions and predominantly those requiring chronic episodes of care. The chronic high priority patients were allocated to staff in both scenarios because priority conditions have first call on staff resources. Because the understaffed scenario took on fewer chronic cases in Year 1, they were able to accept more patients in Year 2, as there were fewer continuing chronic patients from Year 1 (and continuing patients are allocated to staff in preference to new patients). This continues to have an effect on the number of new patients seen throughout the period modelled. This apparent anomaly is therefore just a manifestation of the equivalent of bed blocking in the primary care sector. Clinicians and service managers have endorsed the face validity of the model under these circumstances.

The sensitivity analysis was performed using an arbitrary set of general podiatric and medical conditions which were produced by the sounding board group, with best guess estimates on parameters such as incidence, prevalence and treatment times/frequencies. The parameter which made the greatest proportional change to the unmet need predictions was the average number of treatments to discharge for a particular condition. Under the test parameter set, increasing the number of treatments required for all conditions by 50% increased the unmet need (numbers of patients on the waiting list) by nearly 350% at the end of Year 5. The prevalence and incidence of chronic conditions, especially those identified requiring urgent treatment, also had a disproportionate effect. Doubling the incidence and prevalence of ulcers increased the size of the waiting list by a factor of 3.3 after 5 years.

Discussion

This model was produced primarily as a sensitivity analysis tool for the planning of an epidemiological survey for podiatric conditions. However, its development has been widely welcomed among those involved in planning podiatry services in the NHS and it is now seen as a potential aid for podiatry managers and planners in the future.

The process of rule elicitation with practitioners has also been beneficial. It was apparent during the early stages of discussions with managers, that many of the assumptions underlying the way that services were organised were implicit and often based on historical practice. For many, this was the first opportunity they had had to articulate the principles behind the organisation of their services and this was seen as a benefit of this work in its own right.

Both the sensitivity analysis and the identified "anomaly" referred to above highlight the importance of chronic conditions that require a relatively high number of appointments per episode of care. Conditions which require regular podiatric care over several years appear to have a disproportionate effect on the service. Not only do they require total treatment times in excess of more acute conditions, but they can block access to an understaffed service for those requiring treatment (as, in general, continuing patients will take priority for staff time over new, non-emergency patients). This disproportionate effect was more pronounced when combined with priority status, for example the treatment of ulceration, as these patients are accepted for care even when the department is understaffed.

Staffing reductions can be seen as the outpatient equivalent of decreasing the number of beds in hospital situations, and the priority patients are the equivalent of emergency admissions. The product of time per treatment and annual treatment frequency is the equivalent of length of stay. Previous work on the modelling of bed occupancy has shown that increasing the bed occupancy (or decreasing the total number of beds) has a profound effect on the proportion of rejected patients,[10-12] and this model confirms that if the staffing levels are reduced in Year 1, then the number of rejected patients rises. Furthermore, when staffing levels are increased in Year 2 (and kept constant in subsequent years) then the increased number of patient rejections is still seen in Year 2, as predicted by Bagust et al.[12] However, the disproportionate rejection of non-urgent chronic conditions in Year 1 has the effect of decreasing the average treatment time of the patients seen for several years, and Gorunescu et al[10] have shown how decreasing the length of stay dramatically decreases the probability of rejection. It is the balance of these two competing factors that produces the non-intuitive result of increasing patient throughput after a temporary staffing reduction, and is to the detriment of patients with non-urgent chronic conditions.

Care is needed when interpreting the outputs from this model, and the break-down by condition of the number of patients treated and the numbers waiting for treatment should be examined. The deterministic model cannot provide information about waiting times and when an increase in the number of patients seen is caused by rejection of low priority chronic conditions, those untreated patients may wait for unacceptably long times. Scrutiny of the waiting lists by condition should enable mangers to identify those conditions which are effectively excluded from treatment (or at least under-represented) under a variety of different service configurations.

One of the major difficulties with this modelling process was the lack of good data on the delivery of podiatry services in the UK. This was overcome pragmatically in the development phase of this project by using expert opinion to arrive at parameter estimates. As the model seeks to relate the provision of podiatry services to the podiatric needs of a population, data are required on the prevalences and incidences of podiatric conditions of the local population as well as information about typical treatment plans for these conditions. The epidemiological data are largely absent and should be collected, with the data for those conditions requiring prolonged episodes of care being collected with the highest precision. As validation of the full model is not possible until that information is available, a study is currently in progress to validate the model on the basis of demand (rather than need). To do this three pilot sites have been identified across the UK, all of which assess eligibility for NHS care after a first assessment visit. Data from this first assessment can therefore be used as a surrogate for the epidemiological data relating to demand for that NHS podiatry service (a combination of the incidence/prevalence data and the demand : need ratio parameter in the model). The pilot sites are collecting data on the input parameters to the model and this will then be used to simulate that service and validate the model design.

Although the deterministic model meets the initial requirements for this project, a discrete-event model is currently also being planned, using parameter probability distribution estimates collected as part of the validation study. This would extend the usefulness of the model and enable multiple pathologies to be included more realistically and, most importantly, would allow estimates of waiting times as well as lengths of waiting lists to be made.

Acknowledgements

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Competing interests

Jackie Campbell has a part-time consultancy as Research Coordinator for the Society of Chiropodists and Podiatrists.

References

1 Ladyman. United Kingdom, House of Commons, Written Answers to Questions. Chiropody Services; 3 Feb 2005: Column 1116W. 2005. Available at: http://www.publications.parliament.uk/pa/cm200405/cmhansrd/cm050203/text/50203w30.htm#50203w30.html_sbhd1 (accessed May 2006).

2 Department of Health. The NHS Plan: a plan for investment, a plan for reform. The Stationery Office; 2000.

3 Winterton R. United Kingdom, House of Commons, Written Answers to Questions. Chiropody (Buckinghamshire); 18 Oct 2004: Column 488W. 2005. Available at: http://www.publications.parliament.uk/pa/cm200304/cmhansrd/vo041018/text/41018w17.htm#41018w17.html_sbhd0 (accessed May 2006).

4 Jun JB, Jacobson SH, Swisher JR. Application of discrete-event simulation in health care clinics: a survey. *J Oper Res Soc* 1999; 50: 109-23.

5 Burzykowski T, Molenberghs G, Abeck D, et al. High prevalence of foot diseases in Europe: results of the Achilles Project. *Mycoses* 2003; 46: 496-505.

6 Cartwright A, Henderson G. More Trouble with Feet: a survey of the foot problems and chiropody needs of the elderly. London: HMSO, 1986.

7 Chan MK, Chong LY, Achilles Project Working Group in Hong Kong. A prospective epidemiologic survey on the prevalence of foot disease in Hong Kong. *J Am Podiatr Med Assoc* 2002; 92: 450-6.

8 Garrow AP, Silman AJ, Macfarlane GJ. The Cheshire Foot Pain and Disability Survey: a population survey assessing prevalence and associations. *Pain* 2004; 110: 378-84.

9 Roseeuw D. Achilles foot screening project: preliminary results of patients screened by dermatologists. *J Eur Acad Dermatol Venereol* 1999; 12 Suppl 1: S6-9; discussion S17.

10 Gorunescu F, McClean S, Millard P. Using a queuing model to help plan bed allocation in a department of geriatric medicine. *Health Care Manag Sci* 2002; 5: 307-12.

11 Harrison G, Shafer A, Mackay M. Modelling variability in hospital bed occupancy. *Health Care Manag Sci* 2005; 8: 325-34.

12 Bagust A, Place M, Posnett J. Dynamics of bed use in accommodating emergency admissions: stochastic simulation model. *BMJ* 1999; 319: 155-8. □